MEASUREMENTS TO DETERMINE POTENTIAL INTERFERENCE TO PUBLIC SAFETY RADIO RECEIVERS FROM ULTRAWIDEBAND TRANSMISSION SYSTEMS

J. Randy Hoffman, Eldon J. Haakinson, Yeh Lo[†]

This report describes laboratory measurements to determine the extent and nature of interference to Public Safety radio receivers by ultrawideband (UWB) signals. Two Public Safety radio receivers from different manufacturers were tested in the 138-MHz band, both configured for Project 25 digital radio mode and one additionally configured and tested in analog mode. The laboratory measurements were performed by inserting increasing levels of UWB interference and measuring either bit-error rate (BER) for digital radios or signal-plus-noise-plus-distortion to noise-plus-distortion ratio (SINAD) for one of the same radios placed in analog mode. By varying pulse repetition frequency (PRF), pulse spacing schemes, and gating, a variety of UWB signals were simulated, which were either Gaussian noise-like, sinusoidal, or a hybrid of the two when passed through the receiver passband. Results showed that, when reported in terms of average UWB power in the receiver bandwidth, there is little difference in interference to Public Safety radios when comparing each of the generated UWB signal types. When expressed in terms of signal-to-interference power ratio, where interference power is defined as the power passed through the receiver passband, reference sensitivity (5% BER for digital radios and 12 dB SINAD for analog radios) occurs at approximately 10 dB, with a variation of 2 to 5 dB on either side, depending upon the receiver and signal type. When the interference power is expressed in terms of anything other than the mean power in the receiver bandwidth (e.g., wider bandwidths or peak power), the receiver response can vary greatly depending upon the nature of the interfering signal.

Key words: impulse radio, interference measurement, noise, Project 25, Public Safety radio systems, radio frequency interference (RFI), ultrawideband (UWB)

1. INTRODUCTION

As new wireless applications and technologies continue to develop, conflicts in spectrum use and system incompatibility are inevitable. This report investigates potential interference to Public Safety radio receivers by ultrawideband (UWB) signals. According to Part 15 of the Federal Communications Commission (FCC) rules, non-licensed operation of low-power transmitters is allowed if interference to licensed radio systems is negligible. On May 11, 2000, the FCC issued a Notice of Proposed Rulemaking (NPRM) [1] which proposed that

[†] The authors are with the Institute for Telecommunication Sciences, National Telecommunications and Information Administration, U.S. Department of Commerce, Boulder, CO 80305.

UWB devices operate under Part 15 rules. This would exempt UWB systems from licensing and frequency coordination and allow them to operate under a new UWB section of Part 15, based on claims that UWB devices can operate on spectrum already occupied by existing radio services without causing interference. The NPRM called for further testing and analysis to investigate the risks of UWB interference and ensure that critical radio services are adequately protected.

Conventional methods for measuring and quantifying interference under narrowband assumptions are insufficient for testing UWB interference. Recently, the National Telecommunications and Information Administration's (NTIA's) Institute for Telecommunication Sciences (ITS) studied the general characteristics of UWB signals [2] and the effects of UWB signals on global positioning systems [3] [4]. As a natural extension to these studies, this report describes the investigation of interference from a representative set of UWB signals imposed on a select group of Public Safety radio receivers. The remainder of this section discusses the relevant technologies and associated applications, briefly summarizes related studies, and gives an outline for this report.

1.1 The Technologies

The multifaceted strategic and commercial importance, as well as potential for conflict, of Public Safety radio and UWB systems are summarized in the following subsections.

1.1.1 Ultrawideband Transmission Systems

Unlike conventional radio systems, UWB devices bypass intermediate frequency stages, possibly reducing complexity and cost. Additionally, the high cost of frequency allocation for these devices is avoided if they are allowed to operate under Part 15 rules. These potential advantages have been a catalyst for the development of UWB technologies.

UWB signals are characterized by modulation methods that vary pulse timing and position rather than carrier-frequency, amplitude, or phase. Short pulses (on the order of a nanosecond) spread their power across a wide bandwidth rather than containing it in a narrow band. UWB proponents argue that the power spectral density decreases below the threshold of narrowband receivers, minimizing interference. Other possible advantages are mitigation of frequency selective fading induced by multipath or transmission through materials.

Existing and potential applications for UWB technology can be divided into two groups – wireless communications and short-range sensing. In wireless communications, UWB has been claimed to be an effective way to link many users in multipath environments (e.g., distribution of wireless services throughout a home or office). In short-range sensing

applications, it can be used for determining structural soundness of bridges, roads, and runways and locating objects and utilities underground. Potential automotive uses include collision avoidance systems, air bag proximity measurement for safe deployment, and fluid level detectors. UWB technology is being developed for new types of imaging systems that would assist rescue personnel in locating persons hidden behind walls, under debris, or under snow.

1.1.2 Public Safety Radio Systems

Public Safety agencies, including law enforcement, fire, and emergency medical services, use land mobile radio (LMR) systems for communication of voice and data messages. It is anticipated that UWB applications such as ground-penetration radars and through-the-wall-imaging systems will operate with the spectral region of greatest power located below 1 GHz. The Public Safety user might rely on these UWB systems to operate in close proximity to LMR systems under the same operational scenarios – to provide both vital communications and search/rescue sensor information. For these reasons, it is important to determine the potential of interference to LMR Public Safety radio systems from UWB emissions.

1.2 Scope

The objective of these measurements is to measure the interference by different classes of UWB signals to several different Public Safety radio receivers and to observe and report broad trends in Public Safety LMR performance to this interference. No attempt is made to evaluate specific receiver designs or interference mitigation strategies or provide precise degradation criteria. Recommendations on UWB regulation, likewise, are not addressed and lie under the jurisdiction of the policy teams at NTIA's Office of Spectrum Management and the FCC.

1.3 Organization of this Report

Investigation of UWB interference to Public Safety LMR systems encompasses a broad range of expertise including LMR theory of operation, RF design and hardware implementation, and temporal and spectral characterization of interfering signals. This report completely describes the experiment and is organized as follows.

The first three sections provide orientation and background for the reader. Section 2 describes Public Safety LMR and UWB signal characteristics in order to identify potential interference scenarios and rationalize measurement procedures. Section 3 gives a detailed summary of the measurement system, test procedures, UWB-signal sample space, signal generation details, and hardware limitations. Section 4 provides and summarizes the

measurement results. Conclusions are drawn in Section 5. The appendix provides a detailed description of each UWB type under test.